APPENDIX C

STATIC CODE PROCEDURE

C-1. Introduction

This appendix prescribes the static code procedure for seismic evaluation analysis and upgrading! strengthening requirements for existing buildings in low or moderate seismic regions. The static code provisions in TM 5-809-10/NAVFAC P-355/AFM 88-3, Chapter 13, Seismic Design for Buildings (BDM), are the basis for this procedure. The methodology for this procedure is indicated in figure C-1. This static code procedure will be performed on a project-by-project basis for seismic zone 1 and for nonessential buildings in seismic zones 2 and 3 as determined by approving authority.

C-2. Applicability of the static code procedure

Since the early 1970s, the static seismic provisions of the BDM have been utilized for the evaluation and upgrading of existing military buildings on a project-by-project basis. The static code procedure described in this appendix was used for the evaluation and seismic upgrading of buildings in seismic zone 1 and nonessential buildings in seismic zones 2 and 3. At the discretion of the approving authority, the procedure may also be used for selected high risk and essential buildings (importance factors I = 1.25 and 1.50) and also for buildings in higher seismic zones. The implementation of this procedure will be as authorized by the approving authority.

C-3. Preliminary structural evaluation

The purpose of the evaluation is to determine if the building is in compliance with the acceptance criteria; to identify any structural deficiencies; and to provide the basis for strengthening or upgrading. The preliminary evaluation will be made on the basis of structural analyses performed in accordance with the prescribed seismic forces and allowable stresses of the BDM.

a. Document review. The available "as built" drawings, design calculations, specifications, and other design documents obtained from the using agency will be reviewed by the engineer to identify the lateral force resisting system and other pertinent information. This initial study will compare wind lateral loads to seismic lateral loads on the structure. If the design wind load on the existing structure governs over the seismic load, no further investigation will be required, unless warranted by the irregular configuration and/or other characteristics of the building. If the seismic load governs, the data will be documented (i.e., the lateral load force resisting system) for the site inspection. Also, supplementary notes and/or sketches will be made of the lateral force resisting system, as necessary, to be confirmed by the site inspection.

b. Site inspection. A field examination of the building will be performed and the following observations will be noted for use in the structural evaluation and design of the seismic strengthening or upgrading.

(1) Confirm the structural data indicated on the drawings; particularly with respect to the lateral force resisting system. Note any structural additions or modifications not indicated on the drawings.

(2) Determine the general condition of the structural elements (e.g., corrosion of structural steel, shear cracks in concrete or masonry, and splitting or checking of timber). Note also any damaged or missing members or other deviations from the drawings.

(3) Establish the various load paths by which lateral forces are transferred from the roof or floor systems to the vertical resisting elements (i.e., frames or walls) and to the foundations. Note any discontinuities in the load paths, redundant paths or backup systems and the adequacy of support or anchorage of concrete and masonry walls, at each floor or roof level, for out-of-plane forces.

(4) Note extent and details of anchorage and! or bracing of architectural elements (i.e., partitions, suspended ceilings, curtain walls, parapets, and canopies) and mechanical and electrical equipment (i.e., emergency motor generators and pumps, boilers, cooling towers, critical piping, light fixtures).

c. Acceptance criteria. The basic acceptance criteria for the seismic resistance of existing buildings is based on the provisions of the BDM. However, if an existing building does not conform to the basic criteria, some tolerances are provided in the following paragraphs in recognition that seismic upgrading is an expensive and disruptive process and it may be cost-effective to accept an existing building that is marginally deficient rather than to enforce strict adherence to the criteria.

(1) Conforming systems and materials. When the lateral force resisting structural systems and materials are in compliance with the requirements of the BDM (Refer to BDM paragraph 3-6 for approved structural systems and to BDM chapters

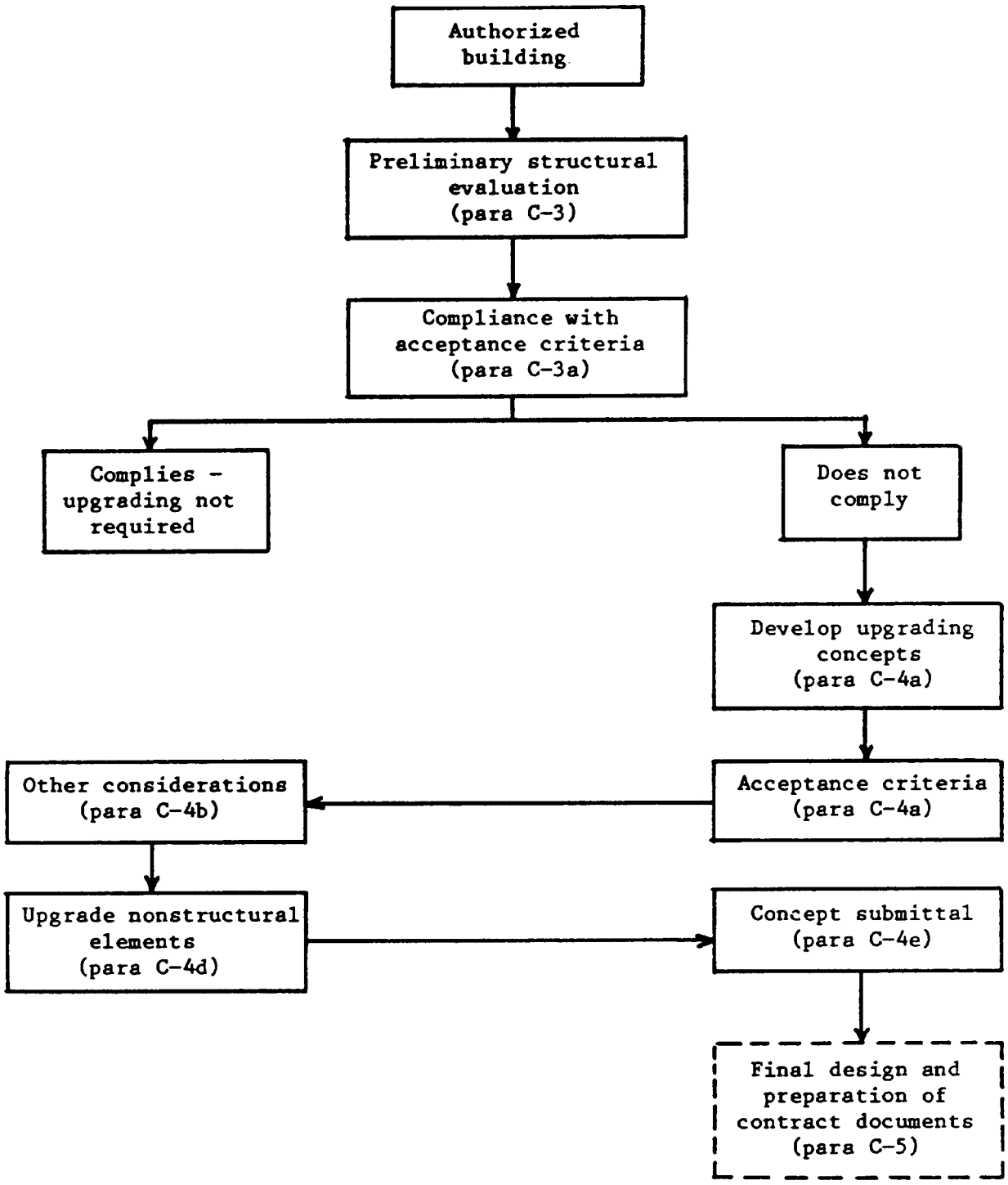

Figure C-1. Methodology for static code procedure

3, 5, 6, 7, and 8 for material requirements), the earthquake demand represented by the lateral forces prescribed in paragraph 3-3 of the BDM may be reduced by a maximum of 20 percent (i.e., to 0.80 of the prescribed force) but the drift limitations will remain as prescribed in paragraph 3-3(H) of the BDM. This is the minimum acceptable level of safety for long-term (more than 5 years) use. If it is not feasible to meet this requirement, plans should be made to phase out the structure.

(2) Nonconforming systems and materials. When the lateral force resisting system or the structural materials do not conform to the approved systems and material specifications of the BDM, justification for acceptability of the existing systems and/or materials is required. Requirements for substantiated data are prescribed below. Acceptance of the approval agency is also required.

(a) Structural systems not specified in the BDM (e.g., “nonductile" moment resistance reinforced concrete frames and unreinforced masonry shear walls) require an analytical evaluation report. The report will include data for establishing the capacity of the system to resist seismic loads and justification for the performance of the system satisfying the intent of the BDM provisions.

(b) Structural materials not satisfying the minimum requirements of the BDM require an evaluation report. Guidelines for evaluation of existing materials are provided in appendix E.

(c) The acceptance criteria for the substantiated noncomplying structural systems and materials are the same as prescribed in paragraph (1), above, except that the drift limitations will be reduced to 80 percent of those prescribed for conforming systems and materials.

d. Methodology for the evaluation. The structural analysis will consist in the application of the prescribed seismic forces to the lateral-force-resisting system of the building in the same manner as for new construction.

(1) In older existing buildings, particularly those not specifically designed for seismic forces, in addition to investigation of the primary structural elements (i.e., shear walls, frames, bracing), attention will be paid to the investigation of possible deficiencies in the design of floor and roof diaphragms, including necessary chords, drag struts, shear transfer to vertical resisting elements, and support or anchorage of concrete and masonry walls for out-of-plane forces (see chapter 5 of the BDM). The resulting stresses in the various structural elements will be combined with the dead and live load stresses as prescribed in the BDM and compared with the allowable stresses. Structural elements that are found to be over-stressed will be evaluated as to their importance to the stability or integrity of the structure. For example, moderate overstress in flexural members of redundant systems (e.g., ductile steel or concrete frames) may not lead directly to structural failure until other mechanisms occur (e.g., buckling, P-delta instability, or shear failure). In a similar manner, shear overstress in a minor shear resisting element of a concrete building may not be of serious consequence if other shear resisting elements are available to resist the redistributed forces from the overstressed element.

(2) For an existing building with identified deficiencies (e.g., overstress in a primary shear wall, diaphragm, column, or brace), an overstress ratio will be calculated. This value is defined as the ratio of the calculated stress in the most overstressed primary structural elements to the allowable stress prescribed by the BDM for that element. The base shear capacity of these buildings shall be calculated by dividing the design base shear (i.e., the base shear from the BDM provisions as used in the evaluation) by the over-stress ratio.

e. Report. A report will be prepared to summarize the results of the preliminary evaluation. The report will include the following items.

(1) Basic design data; i.e., design loads and properties of materials.

(2) Description of preliminary evaluation process.

(3) Method of analysis for each structural type.

(4) Description of each building analyzed including lateral force resisting system, assumed structural properties, etc.

(5) Design calculation with results of analyses, i.e., overstress ratios, and base shear capacities including a conclusion on the acceptance of the existing structure.

(6) Recommended upgrading design concepts and preliminary cost estimates.

C-4. Development of design concepts

Based on the results of the preliminary evaluation and the identified deficiencies with respect to the acceptance criteria of the various structural elements or systems, three alternative upgrading design concepts will be developed unless it is obvious that only one concept can be economically justified.

a. Acceptance criteria. The minimum design criteria for the development of concepts for seismic upgrading of existing buildings will be substantially in accordance with the applicable provisions of the BDM as required for new construction (exact compliance with all details is not required). Nonconforming structural systems or materials (e.g., unreinforced masonry and nonductile reinforced concrete frames) may be retained in the upgrading concept provided an evaluation analysis is submitted to demonstrate that the nonconforming elements are precluded from collapse and do not constitute a hazard to life safety when subjected to the BDM forces and deformations.

b. Other considerations. In addition to compliance with the acceptance criteria, the development of alternative concepts for seismic upgrading will address the general considerations prescribed in paragraph 6-3*a* of this manual. It will be recognized that it may not be feasible and/or cost effective to completely satisfy all of these considerations in the strengthening or upgrading of an existing building. However, in many cases, the engineer has the option of designing the structural modifications at little or no additional cost and the building is not only made stronger, but its response is also improved by reduction of torsional eccentricity or

other undesirable characteristics.

c. Strengthening techniques and options. Generally, the strengthening options are simple and obvious (e.g., a braced steel frame building may need heavier or additional bracing or a concrete flat slab building may be strengthened with new shear walls with minimal impairment of the building function); however, in larger and more complex buildings (e.g., hospitals), the most cost effective solution may require detailed studies. All feasible options should be considered schematically and the three best alternatives selected for concept development. Chapter 6 of this manual presents representative strengthening techniques and options for various structural systems. Combinations or variations of these options may be developed to suit specific buildings.

d. Upgrading of nonstructural elements. Evaluation of the adequacy of supports, anchorages, or bracing of nonstructural elements will be performed for compliance with the requirements of chapters 9 and 10 of the BDM.

e. Concept submittal. A concept submittal will be prepared for review and approval by the approval authority. The submittal will comply with agency standards. The design effort represented in a concept submittal will generally represent 25 to 35 percent of the effort required to complete the design of normal projects, but this figure could be higher for structural modifications. The concept submittal will include the following elements:

(1) *Basis for design.* This will include the acceptance and design criteria; a summary description of the deficiencies identified in the structural analysis; a narrative description of the alternative upgrading concepts; and justification for the recommended concept including construction phasing when appropriate.

(2) *Concept drawings.* Drawings and/or sketches will be prepared to illustrate the recommended concept. The drawings must be adequate to describe the nature, extent, and location of work required and, as a minimum, will include foundation and framing plans, typical sections, and typical connection details.

(3) *Calculations.* Edited, checked, and indexed calculations will be included in the submittal to support the design of upgrading modifications.

(4) *Outline specifications.* Outline specifications will be prepared to describe the type and grade of structural material and procedures by reference to standard or industry specifications.

(5) *Cost estimates.* The concept submittal will include construction cost estimates for the alternative concepts as well as the recommended concept. These estimates shall be sufficiently accurate and detailed for budgeting and programming.

C-5. Final design and preparation of contract documents

Upon authorization of the approval authority, the final design of the approved concept will be implemented and the necessary project construction documents will be prepared in accordance with the requirements of the BDM.

a. Final design. The final design will be done on the basis of the results from the structural analysis and the development of design concepts as directed by the approval authority. The final design will include a complete analysis of the upgraded structure, completed drawings of all details for the project, and a detailed cost estimate. The final documents will be complete in themselves, without the need to refer to the previous analysis and development work.

b. Preparation of project documents.

(1) *Design analysis.* A design analysis, conforming to agency standards, will be provided with final plans. This analysis will include seismic design computations for the determination of earthquake forces on the building, for the structural evaluation of the existing building, and for the upgrading of the existing structure, including stresses in the lateral-force-resisting elements and their connections, and the resulting lateral deflections and interstory drifts. The first portion of the design analysis, called the Basis of Design, will contain assumptions made with regard to selection of dead, live, and seismic loads; allowable stresses for all original and new structural material; description of the existing structural system and the structural system selected for upgrading the building to resist lateral forces; and a discussion of the reasons for its selection. If irregular conditions exist, a statement describing special analytical procedures to account for the irregularities will be submitted for review and approval by the approval authority. The Basis of Design will also indicate any possible future expansion for which provisions are made.

(2) *Drawings.* Preparation of drawings will conform to agency standard.

(3) *Specifications.* Preparation of specifications will conform to agency standards for ordinary construction with additional specific requirements that relate to seismic construction and to upgrading of existing construction.